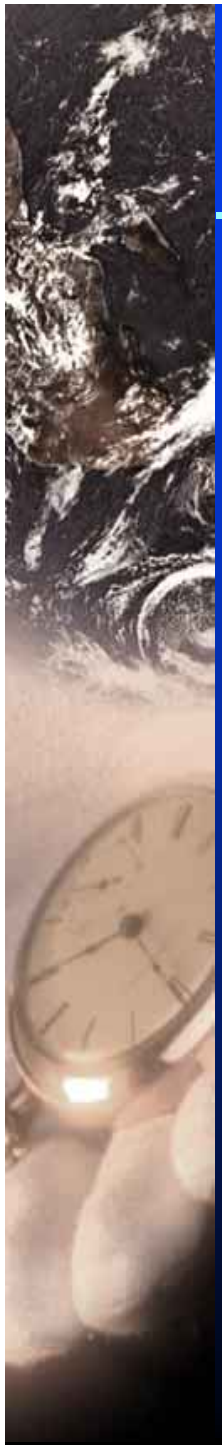
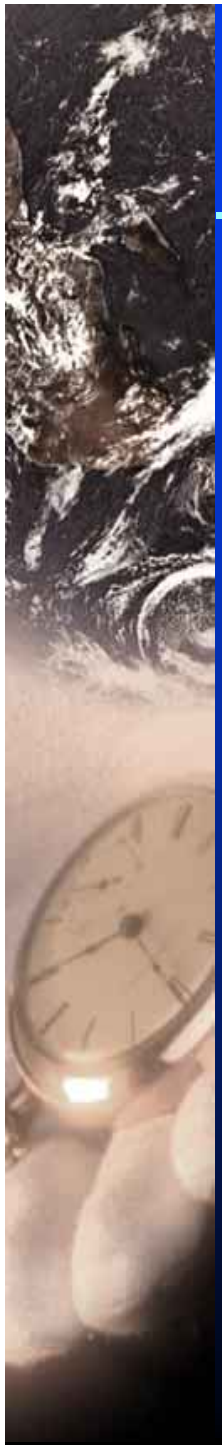

NEXT GENERATION
NATURAL GAS VEHICLE PROGRAM



Meeting Agenda

✔ Welcome, Introduction and Objectives	Paul Norton
✔ Overview of Data from NGNGV Meetings	Denny Stephens
Analysis of Data and Round 1 RFP Recommendations	
Presentation	Paul Norton and Denny Stephens
Discussion	All
Decision Process	All



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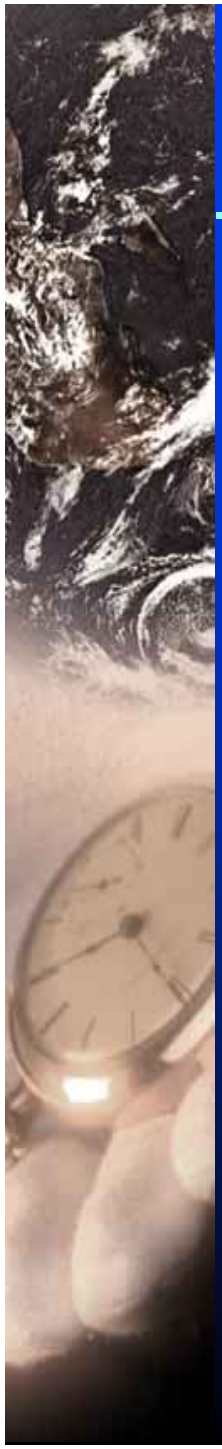
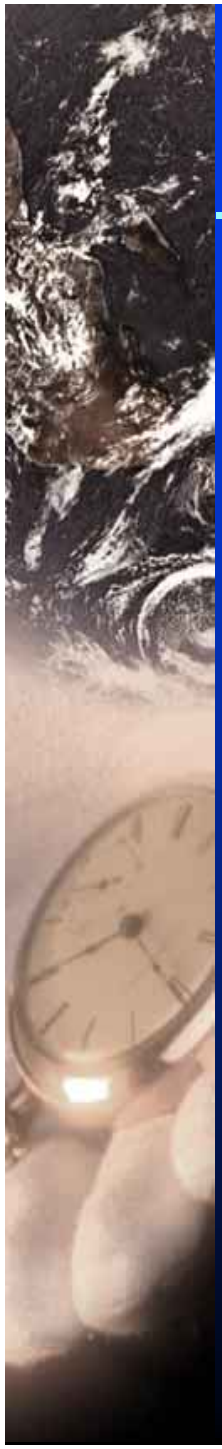


Program Objectives

One medium-duty (Class 3-6) CNG vehicle and one heavy-duty (Class 7-8) LNG vehicle will be available in 2004 that:

- Implement advanced DOE natural gas and heavy-vehicle technologies
- Implement high efficiency engine technology
- Implement step change in technology over current NG vehicles
- Have exhaust emission levels below proposed emission standards for 2007
- Are fully competitive with diesel vehicle counterparts in terms of performance and life-cycle economics
- Are commercially viable

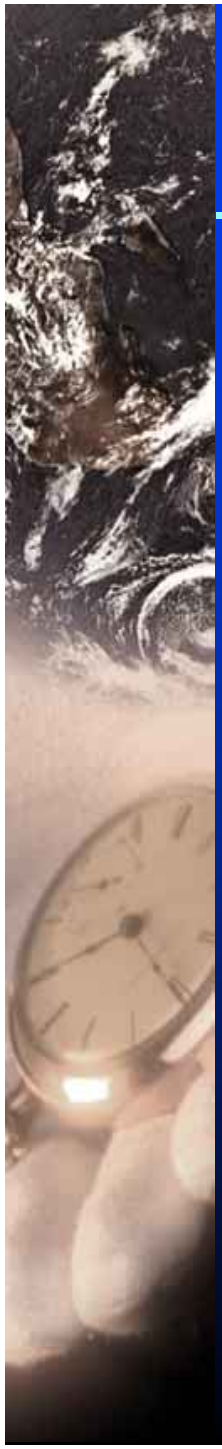


Two Round of Research

Round 1
FY2001
Enablin
Technolo

Round 1
technology R&D that...

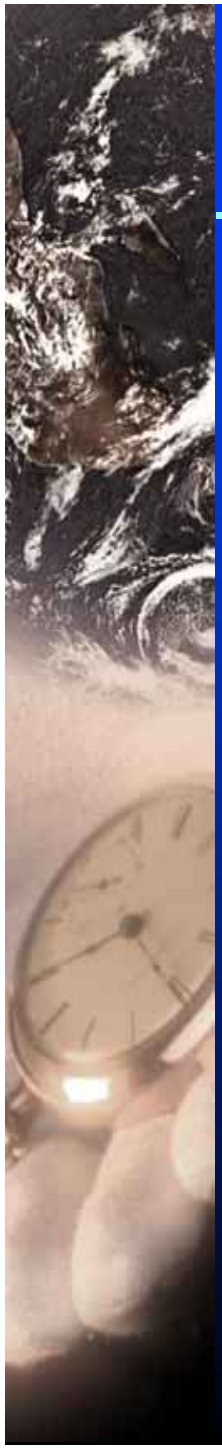
- is close to completion
- could be completed with a relatively short, focused research effort
- could be made commercially viable in the 2004 time frame
- overcomes current barriers to natural gas vehicle introduction



Program Timeline

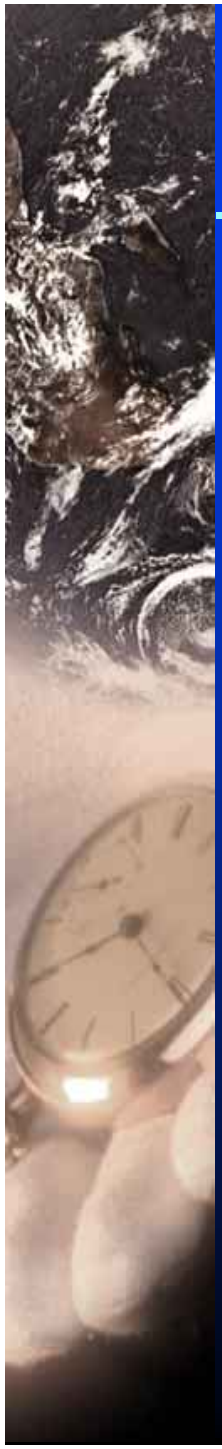
Year 2001

- Release Round 1 RFP - **March**
- Initiate Round 1 Research
- Gather Round 2 Recommendations
- Continue discussions with potential customers
- Secure 2002 Funding



Objective

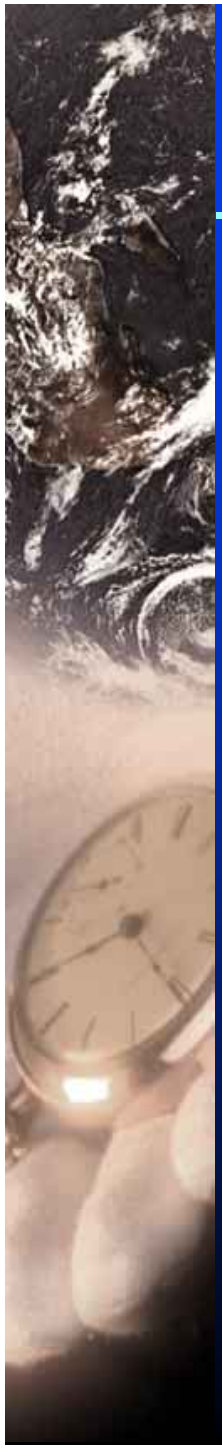
Create list of technologies that will be included in Round 1 research



Outcomes

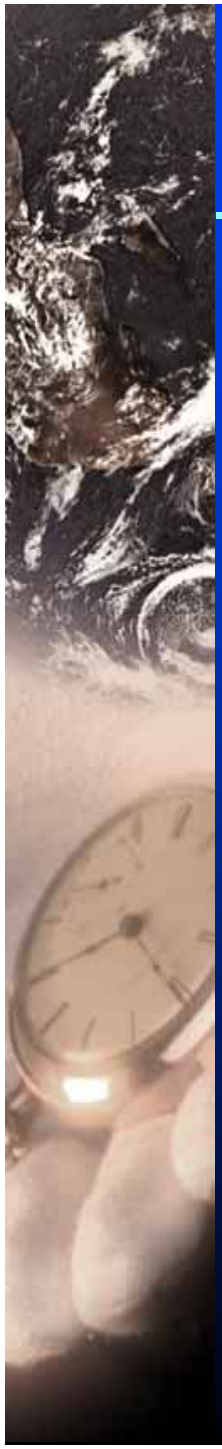
What Vehicles??

What Technologies??



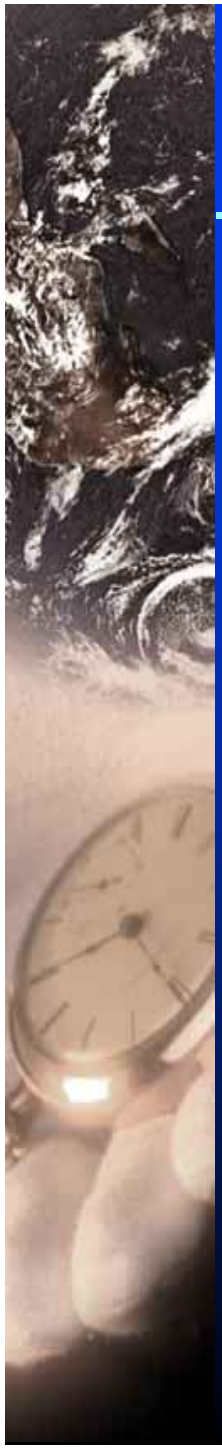
Deciding on our recommendations

- Begin with top recommendations from the Working Group
- Pass all data through filtering questions to reduce the number of technologies.
- All reasoning is on the walls
- Open discussion with all participants
- Vote on vehicle type and technologies
- Write-up recommendations of the group for the funding partners



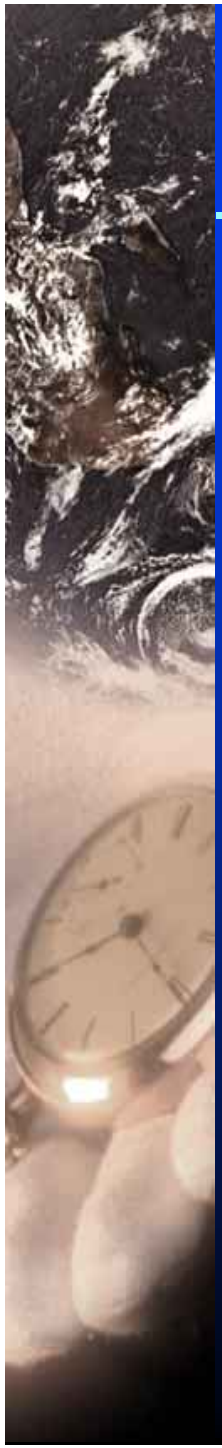
Outcomes

What Vehicle Types??



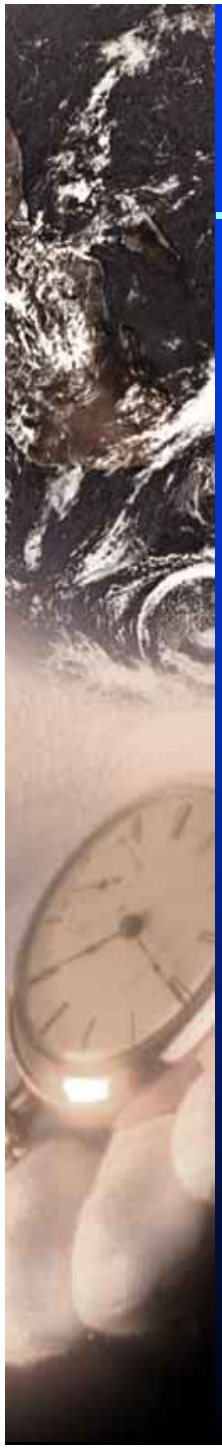
CNG Vehicle Recommendation Data

	Mail/Package	Local delivery	Shuttles
1st VWG Meeting			
Customers	40	12+10=22	32
MD CNG Type	54 "Delivery Truck"		35
Clean Cities	0	0	5
NYC Workshop	3		0



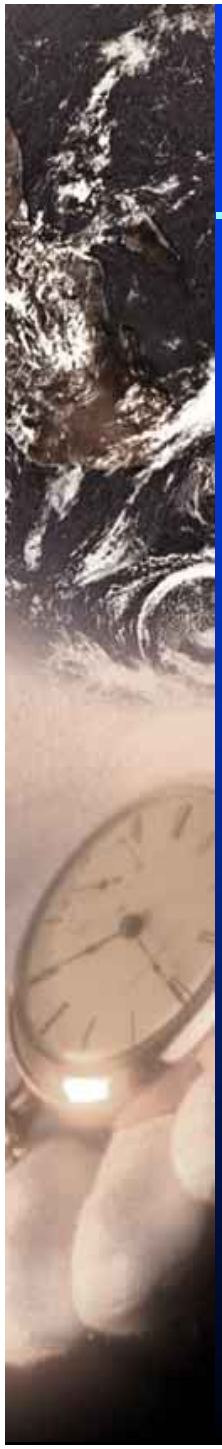
LNG Vehicle Recommendation Data

	Refuse Truck	Short Haul	Long Haul
1st VWG Meeting			
Customers	26	34	13+16 = 29
HD LNG Type	60 "In City Route Trucks"		29
Clean Cities	6	0	0
NYC Workshop	4	1	0



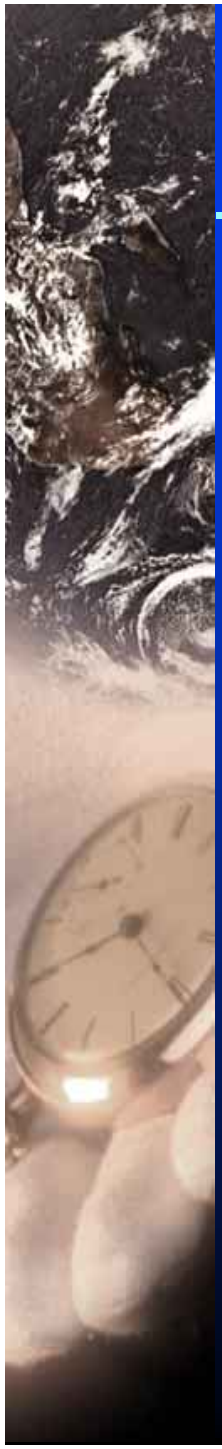
What Vehicles - considerations

- Customers - Large Fleets preferred
- Multiple Locations/Incentives/Mandates/etc.
- OEMs who will build the trucks
- Vehicles were the Program can make a difference



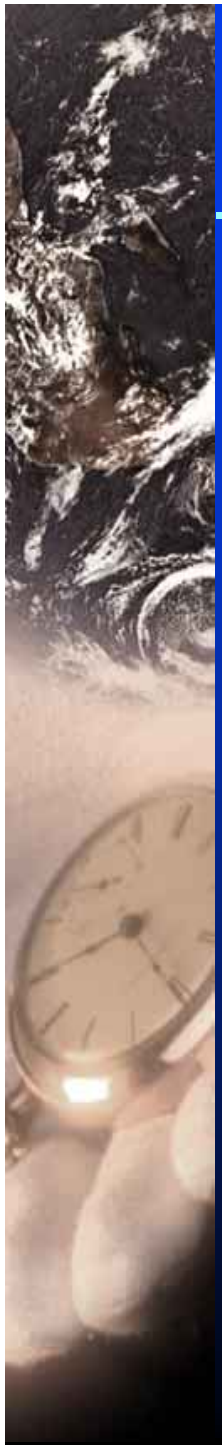
What Vehicles - CNG

- Customers - Large Fleets preferred
  - Package delivery: UPS, USPS, FedEx
  - Local delivery and shuttle: small fleets
- Multiple Locations/Incentives/Mandates/etc.
  - All: nationwide
- OEMs who will build the trucks
  - Package delivery: FL Custom Chassis, Grumman
  - Shuttle: Many
- Vehicles were the Program can make a difference
  - Package delivery: few models available
  - Shuttle: nearly all small bus manufactures, some second or third generation



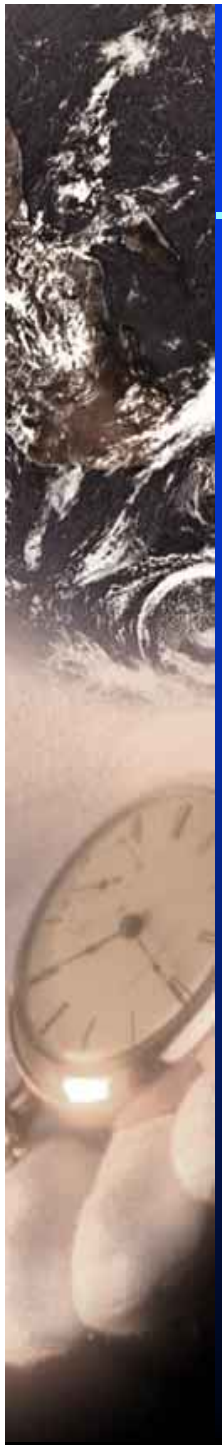
What Vehicles - CNG

Straw recommendation:
Package Delivery Truck
(Step Van)



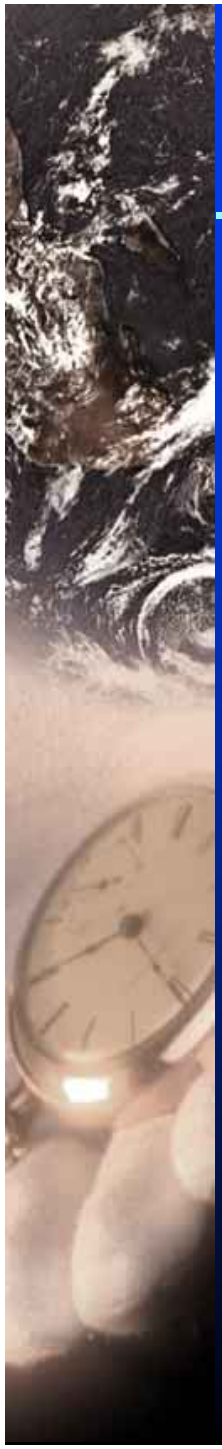
What Vehicles - LNG

- Customers - Large Fleets preferred
  - Refuse: Waste Management
  - Short Haul: many small fleets
- Multiple Locations/Incentives/Mandates/etc.
  - Refuse: CA, NYC, PA, seems to be national interest
  - Short Haul: Mostly CA focus (Prop 65 lawsuits & Moyer Program)
- OEMs who will build the trucks
  - Refuse: Mack, Peterbilt, Crane Carrier already involved
  - Short Haul: Freightliner, Western Star, Mack involved
- Vehicles were the Program can make a difference
  - Several options of each type are available



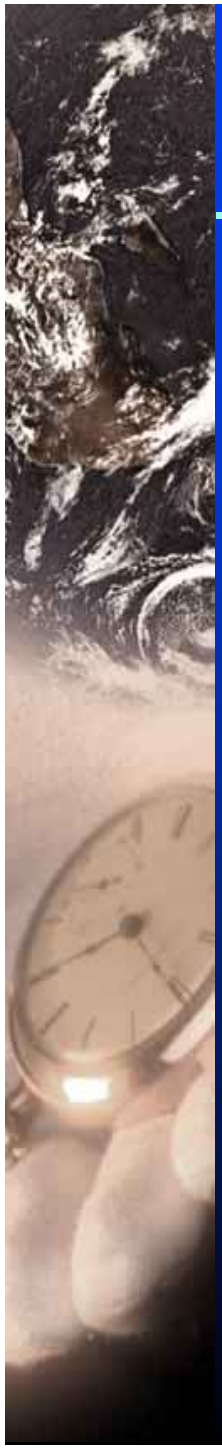
What Vehicles - LNG

Straw recommendation:
Refuse Truck



Outcomes

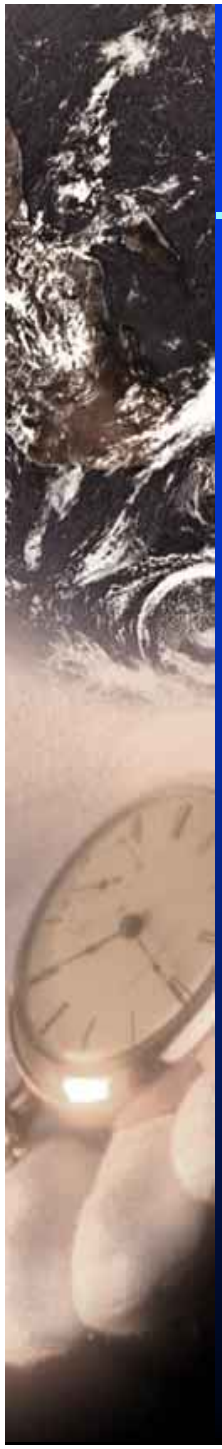
What Technologies??



Narrowing Down the Technologies

32 pages of recommendations
from the 1st NGNGV Working Group Meeting

Short list of technologies
for Round 1 research



Progressive Filters

1. High Votes from the Working Group?

Yes

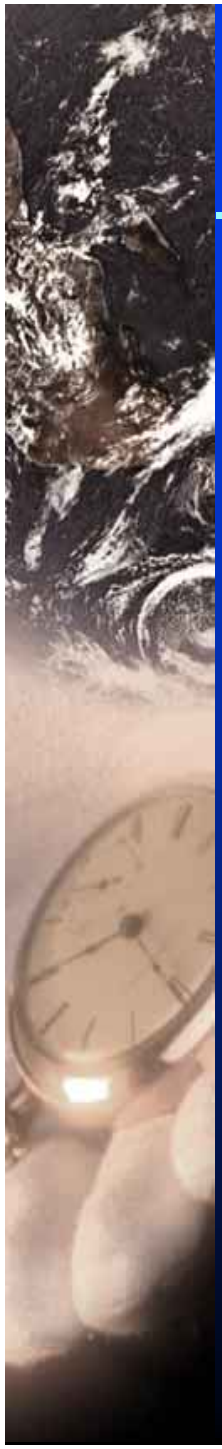
2. Can it be ready for the 2004 prototype vehicles?

Yes or Maybe

3. Is the work being covered outside of the NGNGV program?

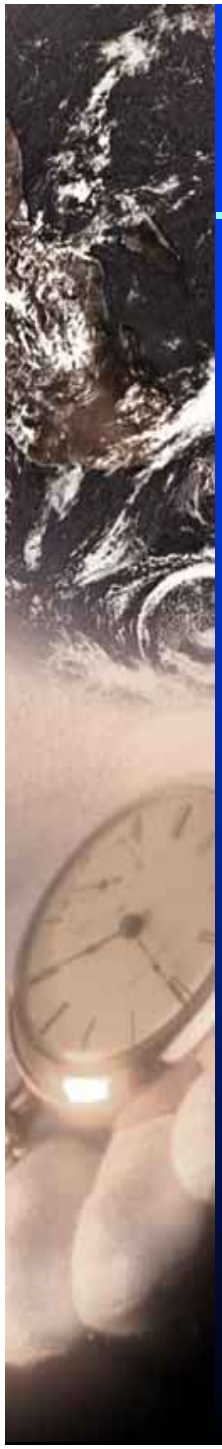
No

Straw Recommendations



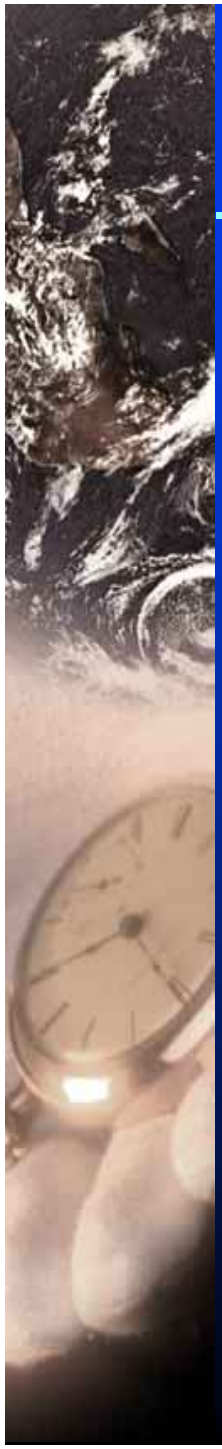
CNG fuel system and storage

High Vote Items	Ready for 2004?	Covered elsewhere?
On-board cylinder monitoring (23)		
- damage indicator coating	Yes	Yes (GTI, DOE, SCAQMD…)
- acoustoultrasonics	Maybe	Yes (GTI, DOE, SCAQMD…)
- fiber optics	No	
- others?		
Lower cost cylinders (21)	Yes	Yes (GTI + DOE)
Temp. comp. fueling (16)	Yes	Yes? (IWG considers solved)
Accurate metering (11)	Yes	Yes? (IWG issue)



LNG fuel system and storage

High Vote Items	Ready for 2004?	Covered elsewhere?
Standard receptacle (21)	Yes	Yes? (SAE? Standards or tech need?)
Low pressure storage (18)	Yes	? (DOE/BNL)
Venting mgnt. (15)	Needs clarification - what technology?	
Lower cost tanks (14)	Yes	Yes? (DOE/BNL)
Fuel sys. integration (14)	Yes	No?
Onboard fuel gauge (11)	Yes	No? (recommended by IWG)
Tank defueling (7)	Yes	No



Body and Chassis - CNG

Approach #1

Use existing body and chassis and fit tanks to it

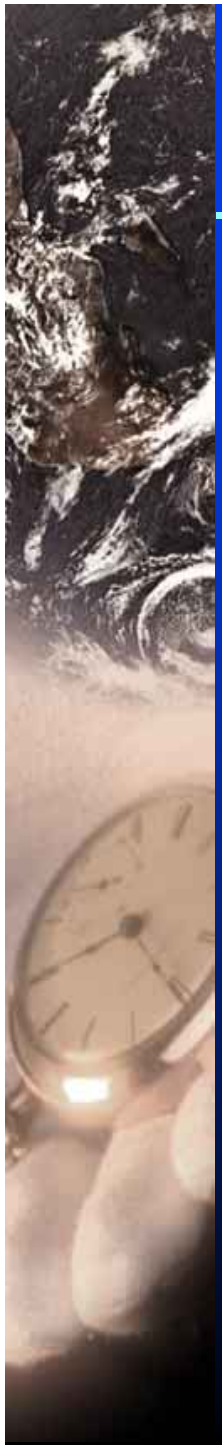
Approach #2

Design body and chassis to accept large CNG cylinders

Compromise

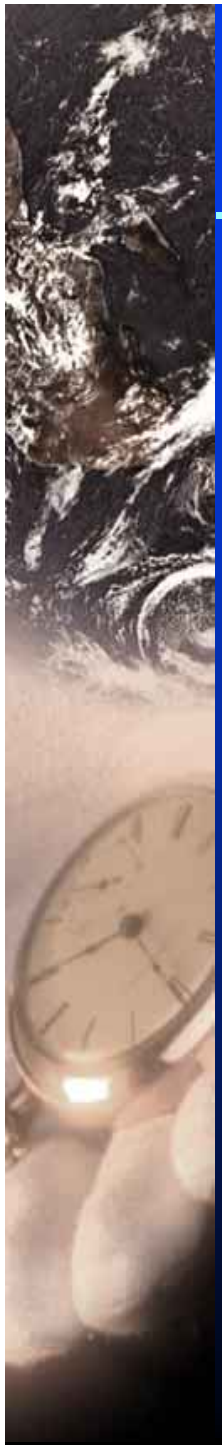
Work with OEM to create next generation chassis and body that can be used with NG or diesel

Include in Round 2 RFP



Body and Chassis - CNG

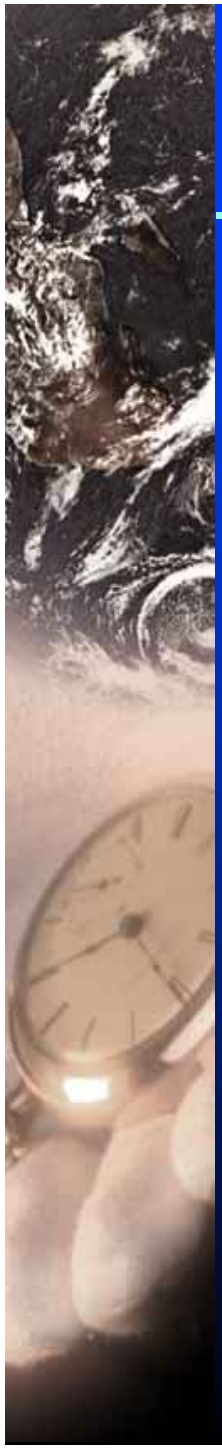
High Vote Items	Ready for 2004?	Covered elsewhere?
Conventional look (19)	Yes	Yes (product spec for Round 2)
CVT (12)	?	?
Fill time < 5 min (11)	Yes	Yes (product spec for Round 2)
Maint. cost ≤ diesel	Yes	Yes (product spec for Round 2)



Body and Chassis - LNG

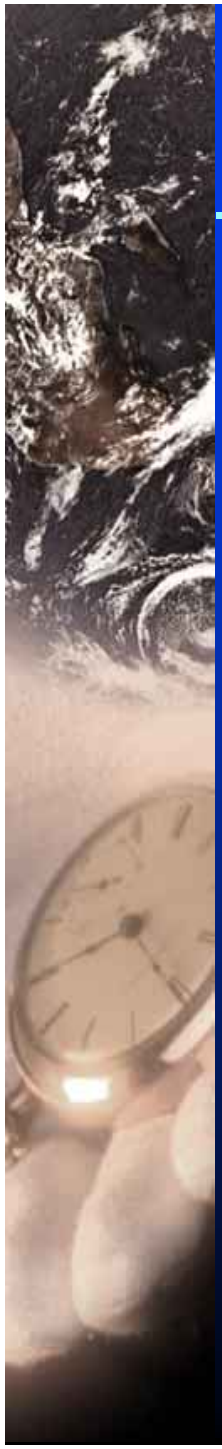
High Vote Items	Ready for 2004?	Covered elsewhere?
Anti-idling (19)		
NG APU (9)	n/a (long-haul)	? (DOE - Sid Diamond)
Incorporate SAE standards (16)	Yes	Yes (product spec for Round 2)
Conventional look (14)	Yes	Yes (product spec for Round 2)
Adv. Crash protection (11)	Yes	No?
Chassis OEM willing (15)		
Involve customer (6)		

Tasks for the Outreach and Communications Team



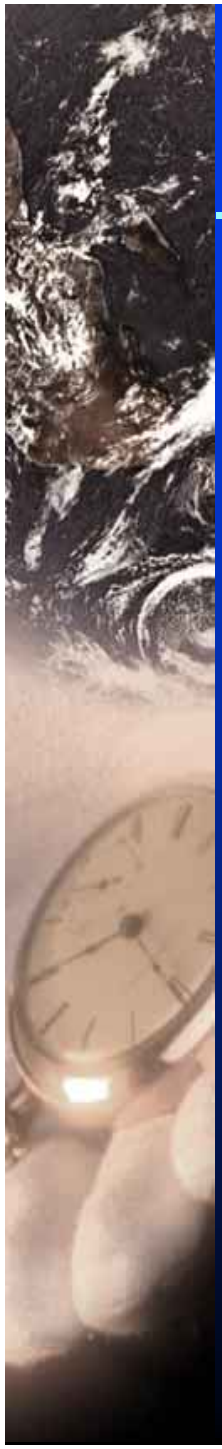
Body and Chassis - LNG

High Vote Items	Ready for 2004?	Covered elsewhere?
Anti-idling (19) NG APU (9)	n/a (long-haul)	? (DOE - Sid Diamond)
Incorporate SAE standards (16)	Yes	Yes (product spec for Round 2)
Conventional look (14)	Yes	Yes (product spec for Round 2)
Adv. Crash protection (11)	Yes	No?
Chassis OEM willing (15) Involve customer (6)	Tasks for the Outreach and Communications Team	



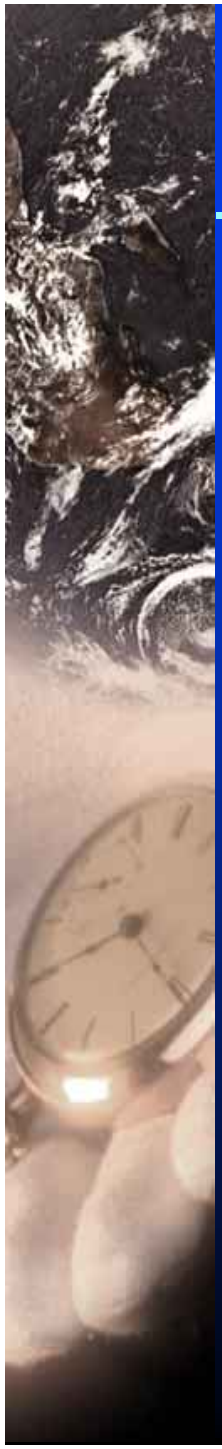
Body and Chassis - LNG

High Vote Items	Ready for 2004?	Covered elsewhere?
Adv. Cooling system components (13)	Yes	Yes (engineering rather than R&D, product spec for Round 2)
Driveline optimization w/torque curve (12)	Yes	Yes (engineering rather than R&D, product spec for Round 2)



Engine Type

High Vote Items	Ready for 2004?	Covered elsewhere?
DING (21)		
- glow plug ignition	No	Yes (DOE/NREL)
- pilot ignition	Yes? (emissions targets?)	Yes? (DOE/NREL, SCAQMD, CEC Low-NOx project)
SING (18)	Yes? (emissions targets?)	? (Many projects)
Rich Burn w/EGR (17)	Yes	No



Engine Issues

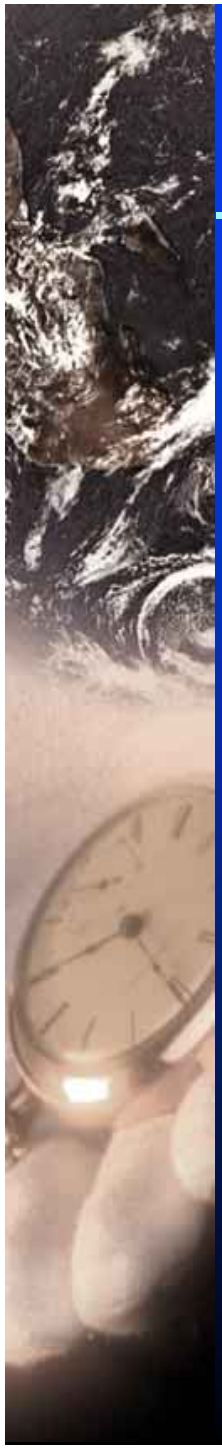
1st NGNGV meeting set the following emissions targets:

- 0.5 g/bhp-hr NOx
- 0.01 g/bhp-hr PM

EPA and CARB are proposing new 2007 standards:

- 0.2 g/bhp-hr NOx
- 0.01 g/bhp-hr PM

Should we adopt the EPA and CARB proposed 2007 standards as our target?



Engine Issues

Will there be an engine ready for the NGNGV prototypes that meet the emissions targets?

Not under current project plans

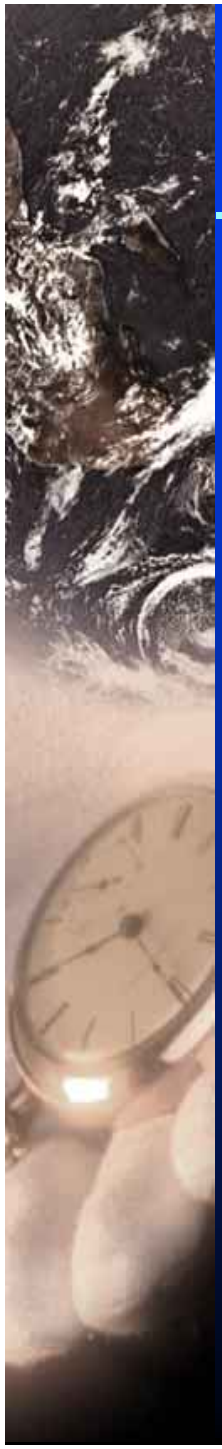
Closest projects:

HD engine: Low NOx engine project

- High HP
- 0.5 g/bhp-hr NOx
- 0.10 g/bhp-hr PM
- Emissions testing in 2002

MD engine: Deere 6081, Cummins B5.9, C8.3

- 2.0 g/bhp-hr NOx today



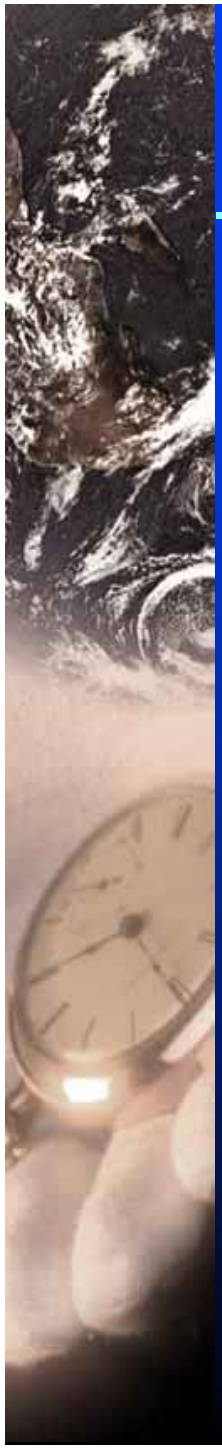
Engine Issues

Consent Decree: Major engine manufacturers will have to meet 2004 standards in late 2002:

- 2.5 g/bhp-hr Nox+HC
- 0.10 g/bhp-hr PM

NG engines must have lower emissions than diesel engines to maintain the NGV market.

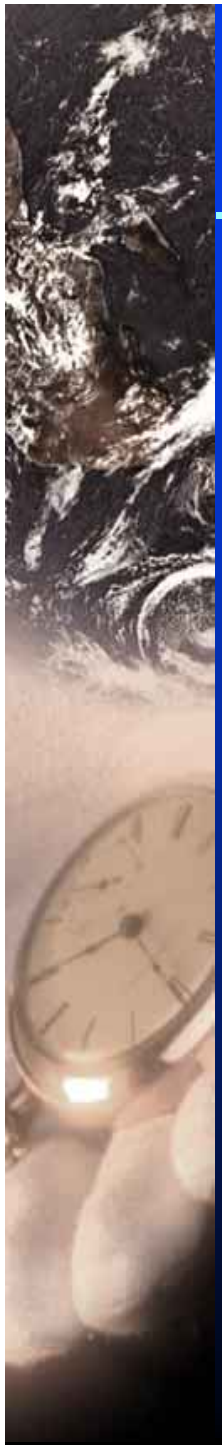
Therefore the Consent Decree affects current NG engine development emissions targets.



Engine Issues

SING lean burn engines:

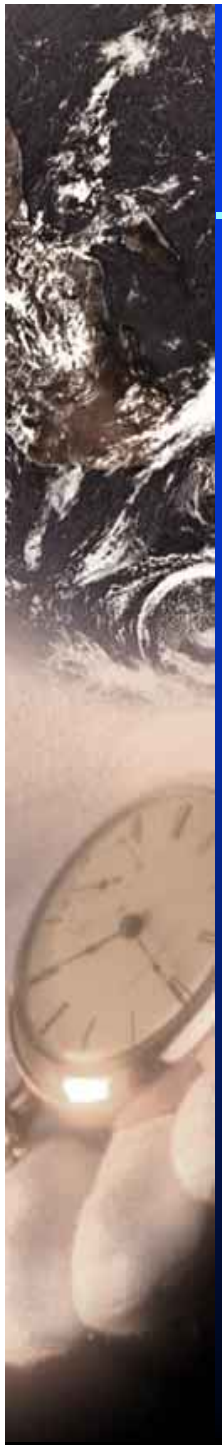
- There are a host of near term projects underway or recently completed:
  - Cummins 8.3G+
  - DDC S60G
  - Mack E7G
  - Deere 6081
  - etc.
- None of these will produce and engine with the NGNGV emissions targets or with lower emissions than diesel in 2002.
- Will most likely require NOx aftertreatment to meet NGNGV emissions targets.



Engine Issues

Rich Burn (stoichiometric) engines:

- There are no programs underway to develop this concept.
- Can use a 3-way catalyst to meet NGNGV emissions targets as well as low HC emissions.
- Has lower efficiency than a lean-burn engine.



Engine Issues

Suggestion:

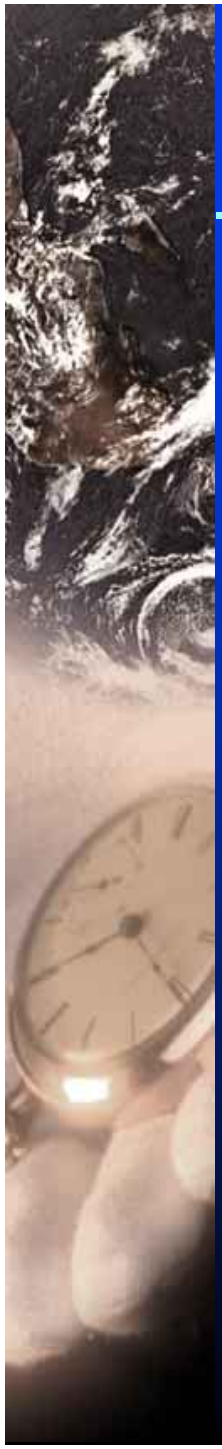
If we pursue engine development as part of the NGNGV program…….

- Set emissions targets and timeframe
- Let manufacturers propose the technology approach

Engine Type

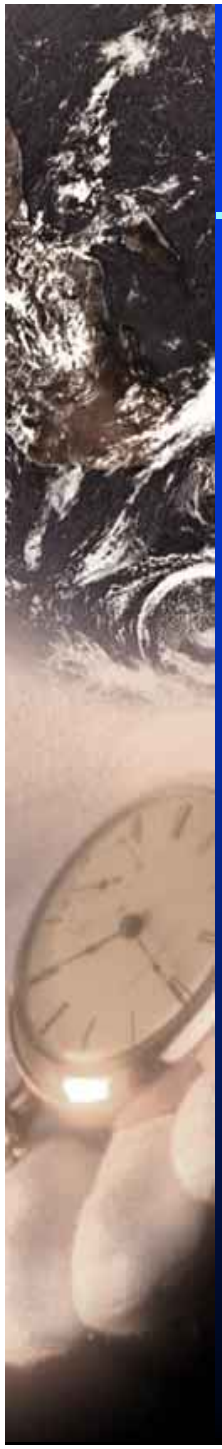
High Vote Items	Ready for 2004?	Covered elsewhere?
DING (21)		
- glow plug ignition	No	Yes (DOE/NREL)
- pilot ignition	Yes? (emissions targets?)	Yes? (DOE/NREL, SCAQMD, CEC Low-NOx project)
SING (18)	Yes? (emissions targets?)	? (Many projects)
Rich Burn w/EGR (17)	Yes	No

NG engine with HP and emissions geared to NGNGV needs



NG Aftertreatment

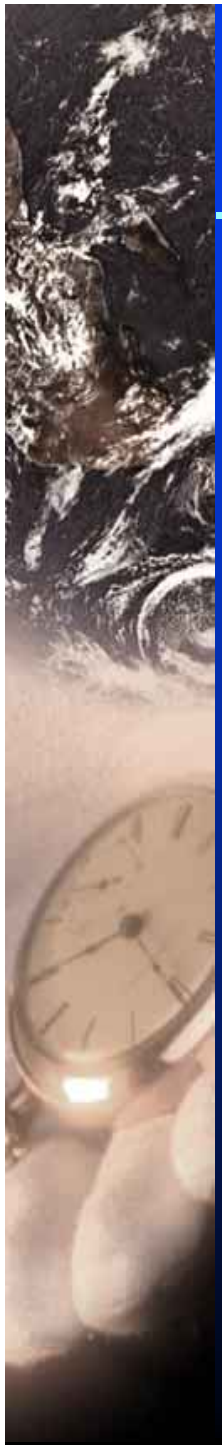
High Vote Items	Ready for 2004?	Covered elsewhere?
Lean NOx catalyst (32)	Maybe	Not for NG
Cat. protect. from sulfur (28)	Yes	Yes (DOE/NREL DECSE, DEC)
Total HC reduction (28)	?	No
Oxidation catalyst (9)	Yes	Yes? (optimize for NG?)



Possible R&D Technologies

LNG fuel systems technologies

1. Standard LNG receptacle (21) [SAE? IWG?]
2. Low cost LNG tanks (14) [BNL?]
3. LNG system design integration (14)
4. LNG fuel gauge (11)
5. Crash protection for LNG tank (11)
6. LNG tank defueling (7)



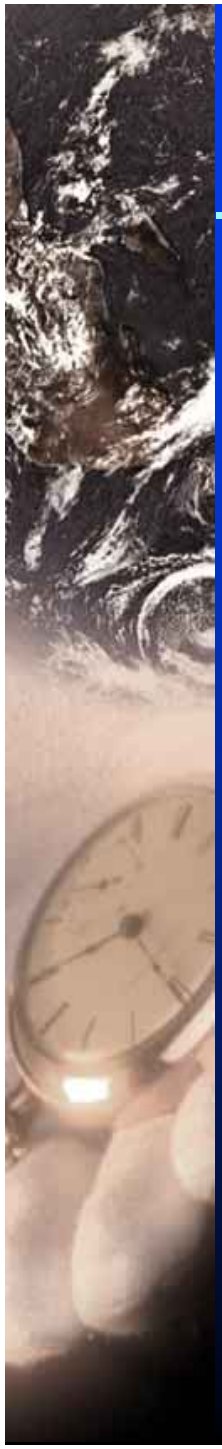
Possible R&D Technologies

Engine and Aftertreatment

7. NG engine to meet NGNGV goals
8. Lean NOx aftertreatment (32) [WVU?]
9. Total HC reduction (28)
10. Oxidation catalyst (9)

Other

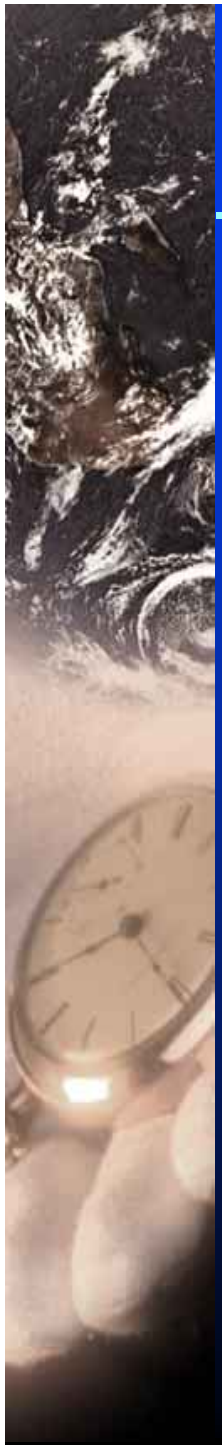
11. Continuously Variable Transmission for CNG truck (12)



Possible R&D Technologies

Benefit	Low Effort	High Effort
High Benefit	"Low hanging fruit" Standard LNG recep. LNG fuel gauge	"Tough nut to crack" Low cost LNG tank CVT for CNG truck NG engine Lean NOx catalyst Total HC reduction
Low Benefit	"Quick hit" LNG sys. Integration LNG tank defueling LNG crash protection Oxidation catalyst	"Why bother?" ✳

Effort and expense to develop



What's Next

- Discuss the process and recommendations
- Vote on the final recommendations